R&R:
Risk and Resilience – what resilience is ***not***

Workshop @ WUR

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Risk

Has multiple uses and interpretation

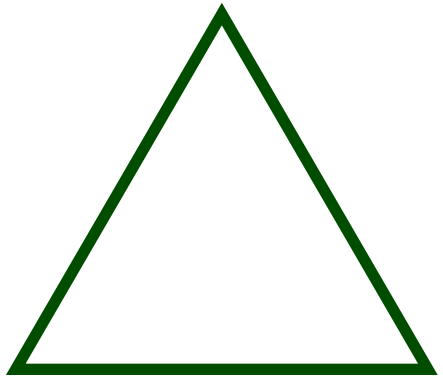
Common definitions:

- Risk = hazard x exposure
- Risk = hazard x exposure x vulnerability

If one factor increases, the risk increases

Hazard:
source of harm

Rare storm or climate change?



Exposure:
presence of people, etc.

One house or a whole city?

Vulnerability:
susceptibility

=

Resilience?

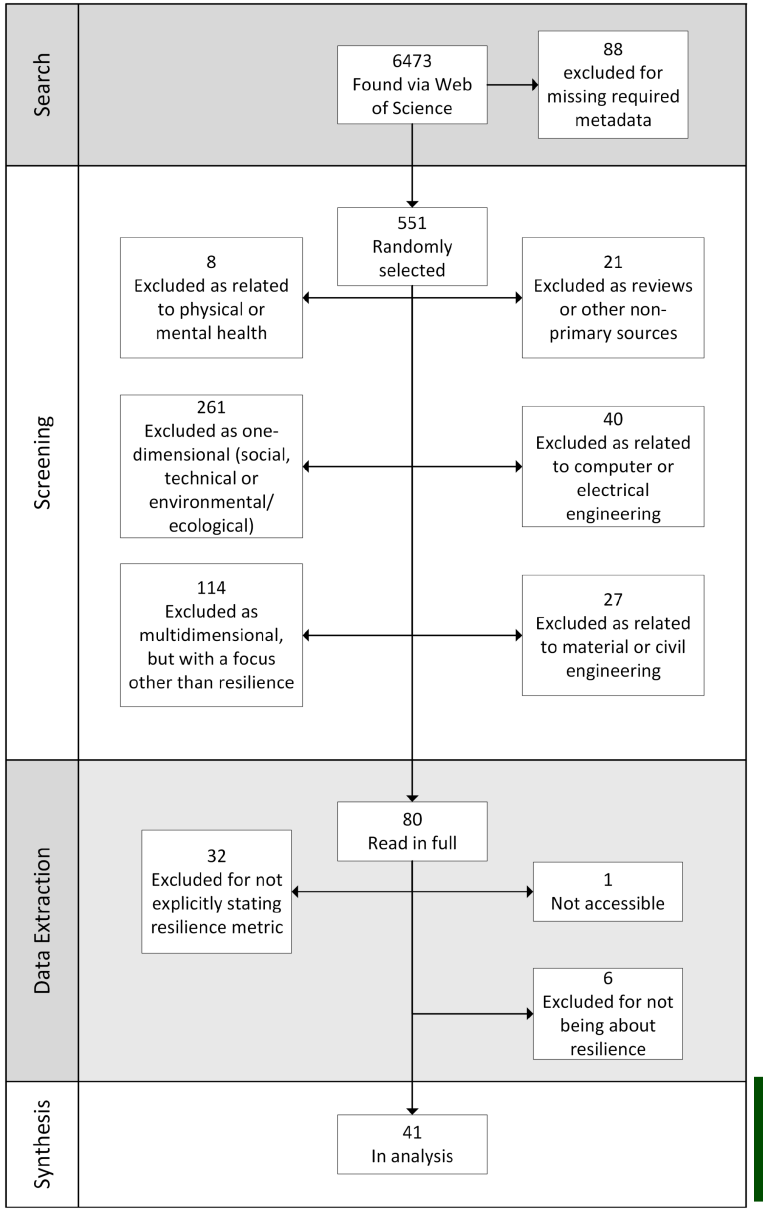
Resilience is a buzzword *(OK, now it's AI, but…)*

Generic definition of Resilience:

"The ability of a socio-technical-environmental system to sustain, improve and innovate its key functions – through absorbing, reacting to, recovering from, adapting to or reorganizing – in response to chronic stresses, abrupt shocks, and disruptions."

Scoping review (Steinmann et al., 2024):

- 6400+ papers mentioning Resilience and Socio-Ecological or Socio-Technical System
- Less than 10% defines Resilience and gives a quantitative approach for it

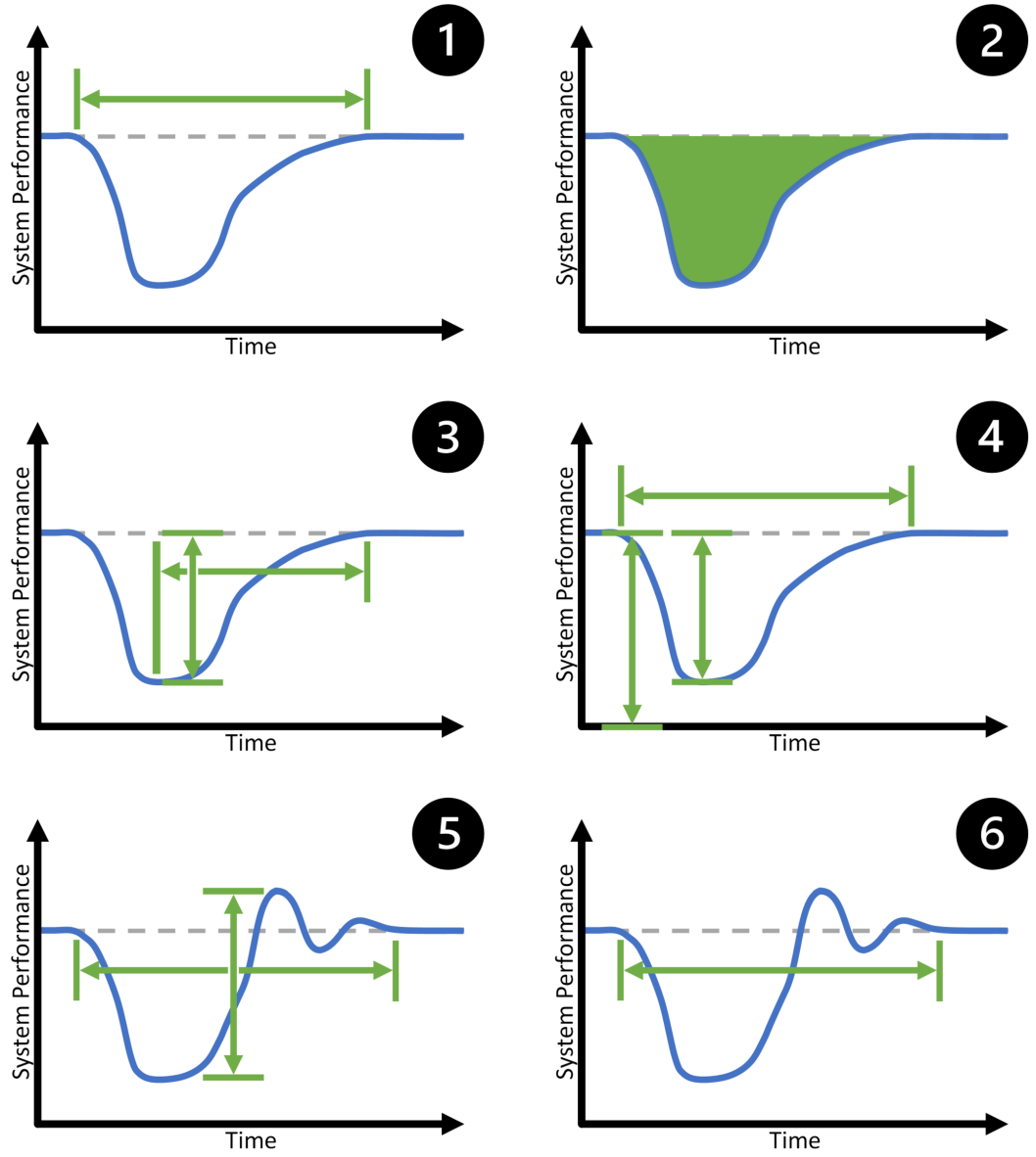


Resilience metrics

Scoping review (Steinmann et al., 2024):

- Resilience metrics are mostly adaptation of return time
- Measures length of recovery or area under the curve
- This is the response

- *How is it resilience?*



Resilience is multi-faceted

Generic definition of Resilience:

"The ability of a socio-technical-environmental system to sustain, improve and innovate its key functions – through absorbing, reacting to, recovering from, adapting to or reorganizing – in response to chronic stresses, abrupt shocks, and disruptions."

For whom?

Why?

Of what?

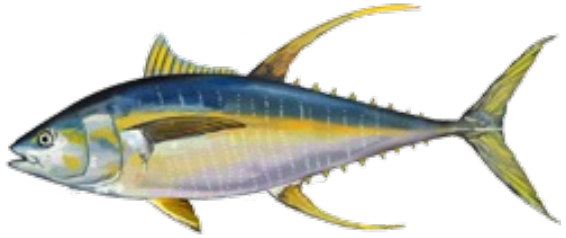
For when and where?

To what?

At what costs or trade-offs?

System complexity

What is the relevant level of detail to include?

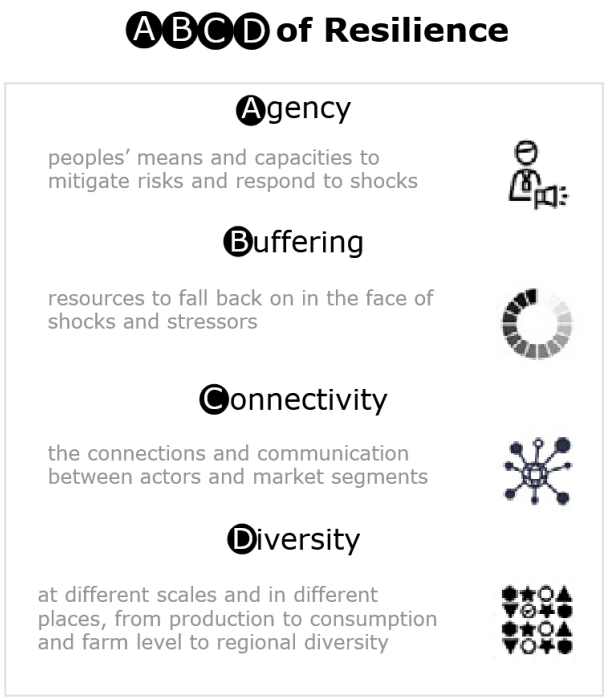


Picture courtesy of Stella Libre

Possible mechanisms underlying resilience (1)

Distinguish between different mechanisms (Fonteijn et al., 2022)

- Not 'the truth', but to illustrate we must think about multiple underlying mechanisms



Possible mechanisms underlying resilience (2)

Feedback

Physical barrier

Storage buffer

Group diversity

Individual diversity

Dispersion (reaction-diffusion)

Evolutionary mechanisms

Strategic behaviour

Adaptation

Learning

Response diversity in institutions (Walker et al., 2023)

Transformability: foresee disasters and their impact and prepare (Levin et al., 2022)

Ten Broeke & Van Voorn (unpublished)

Resilience assessment example (1)

Determine viewpoint: e.g., world bank wants to invest in local smallholder farms

System description: e.g., smallholders, trade networks, consumers

Vulnerable groups: e.g., households depending on local foods

Relevant perturbations: e.g., droughts, pests, price fluctuations, war

Resilience assessment example (2)

Step 2: ABCD properties per actor group				
	Agency	Buffering	Connectivity	Diversity
Smallholder households	Opportunities for productivity development (investment), social status as a limiting factor	Own reserves (cash, livestock, and food)	Local trade and social relationships	Combine farm income with off-farm income
				Crop diversity
Local households depending on local production	Education and social factors enable job opportunities. Ability to migrate	Household cash/food stocks	Social relationships between households	Diversity of local production across farmers
			Trade with other communities, and large-scale traders	Local job opportunities

Determine indicator(s) for each 'cell', e.g., profitability for smallholder farms

Indicate vulnerability, e.g., smallholder farms have low education and financial buffers

Impacts (can be net positive or negative), e.g., improved profitability but increased inequality

Resilience trade-offs

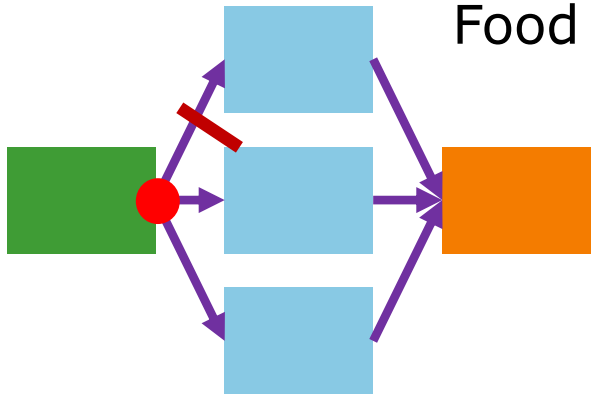
For networks, information theory gives:

Efficiency, ascendency

$$C = A + \Phi$$

Capacity

Reserve, buffer



Food web: $A \downarrow$; $\Phi \uparrow$

Food chain: $A \uparrow$; $\Phi \downarrow$

Social behaviour may create or delete potential links (Van Voorn et al., 2020)

Quantifying resilience: modelling mechanisms

	Mean-field (2.2.1)				Input-Output (2.2.2)	General Equilibrium (2.2.3)	Cellular Automata (2.2.4)	Network (2.2.5)	Game theory (2.2.6)	ABM (2.2.7)
	Standard	Spatial mean-field	Structured population	Adaptive dynamics						
Feedback (3.1)	+ (Bennett et al. 2005)	+	+	+	+ (Okuyama and Santos 2014)	+ (Rose and Liao 2005)	+ (Yang et al. 2020)	+ (Kalisch et al. 2019)	+ (Anderies et al. 2004)	+ (Heckbert 2013)
Physical buffer (3.2)	- (A3)	+ (Dottori and Todini 2013)	- (A3)	- (A3)			+ (Dottori and Todoni 2011)			+ (Dawson et al. 2011)
Storage buffer (3.3)	+ (Hübel and Dahlem 2014)	+	+	+	- (A7)	+ (Carroll and Jeanne 2009)		+ (Nazemi et al. 2019)	+ (Hennet and Arda 2008)	+ (Romić and Nakajima 2018)
Group diversity (3.4)	+ (Ives and Hughes 2002)	+	+	+	+ (Wagner and Deller 1998)	+ (Foster and Rosenzweig 2004)	+ (Alonso and Sole 2000)	+ (Lobry et al. 2008)	+ (Steidinger and Bever 2014)	+ (Schwarz and Ernst 2009)
Individual diversity (3.5)	- (A2)	- (A2)	+ (Lundström 2018)	- (A2)	+ (Kim et al. 2015)	+ (Balistreri and Rutherford 2013)	+ (Ueda et al. 2006)	-	+ (Meng et al. 2015)	+ (Lozano and Arenas 2007)
Dispersion (3.6)	- (A3)	+ (Girard et al. 2016)	- (A3)	- (A3)	+ (Okuyama 2004)	+ (Kajitani and Tatano 2018)	+ (Pérez-Molina et al. 2017)	+ (Nazemi et al. 2019)	+ (Prior et al. 1993)	+ (Grinberger et al. 2015)
Strategic behaviour (3.7)	- (A5)	- (A5)	- (A5)	- (A5)	- (A5)	- (A5)	-	-	+ (Nowak and Sigmund 1993)	+ (Schlüter and Pahl-Wostl 2007)
Adaptation (3.8)	- (A4)	- (A4)	- (A4)	+ (Dercole et al. 2010)	- (A4)	- (A4)	- (A4)	- (A4)	+ (Brown 2016)	+ (Ten Broeke et al. 2016)
Learning (3.9)	- (A2,A5)	- (A2,A5)	- (A2)	- (A5)	- (A5)	- (A5)			+ (Tuyls and Nowé 2005)	+ (Power 2009)

Ten Broeke & Van Voorn (unpublished)

Statements about resilience to feed the discussion

Resilience

- **Is NOT** a metallic spring
- **Is NOT** a ball rolling in a cup
- **Is NOT** generic and hence **cannot** be ***generically*** improved
- **Is NOT** free: there is ALWAYS a trade-off or associated cost

- **Must be** 'disentangled' along multiple viewpoints and mechanisms
- **IS** a social construct
- **IS** specific and can only be ***specifically*** improved **at an expense**